(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 717 505 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
06.11.2002 Bulletin 2002/45

(51) Int Cl.[7]: H04B 1/707, H04J 13/04

(21) Application number: 95308992.7

(22) Date of filing: 11.12.1995

(54) CDMA multiuser receiver and method

CDMA Mehrbenutzerempfänger und Verfahren

Récepteur et procédé à utilisateurs multiples à AMDC

(84) Designated Contracting States:
DE GB IT SE

(30) Priority: 13.12.1994 JP 30900894
12.06.1995 JP 14479095

(43) Date of publication of application:
19.06.1996 Bulletin 1996/25

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Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The present invention relates to a CDMA (Code Division Multiple Access) multiuser receiver and method using spread spectrum, which is suitable for cellular mobile communications.

[0002] DS-CDMA (Direct Sequence CDMA) is a promising candidate of a radio access method for the next generation mobile communications, and intensive research into it has been carried on. The DS-CDMA is a communication method, in which a plurality of users carry out communications simultaneously utilizing the same frequency range, and the individual users are identified by spreading codes. In the DS-CDMA cellular system, interference due to cross-correlation between the spreading codes assigned to the users not only degrades the communication quality, but also limits the capacity in terms of the number of subscribers. This type of interference will further increase owing to multipaths between a base station and mobile stations. Specifically, besides the cross-correlations between different spreading codes, cross-correlations due to receive timing differences between multipaths using the same spreading code cause such type of interference and degrade the communication quality. Thus, interference canceling (or orthogonalization) technique is important.

[0003] The canceling technique in the DS-CDMA is roughly classified into a single user method and a multiuser method.

[0004] The single user method estimates the amplitude and phase of the received signal of an intended channel, followed by the decision, without considering the spreading code information of the other users. This method requires rather a low processing amount and small hardware dimension. It is difficult, however, to apply this method to a system using, as spreading codes, middle codes or long codes, that is, spreading codes with their period longer than that of a symbol, because it has no information on spreading codes of the other users, and adaptively carries out the orthogonalization based on the constancy of the spreading codes of the other users, that is, the fact that the spreading codes are kept fixed for each symbol.

[0005] On the other hand, the multiuser method estimates the amplitude and phase of an intended received signal using information on spreading codes of the entire users, and carries out the orthogonalization between signals of all the users. As the multiuser method, a replica regeneration type or a decorrelator type is known: the former reduces interference by regenerating received signals sequentially beginning from the greatest received power and subtract them from the whole received signal through multi-stages; and the latter cancels interference by forming a correlation matrix using cross-correlations between the spreading codes, and by multiplying its inverse matrix by a received signal vector.

[0006] Generally, more effective interference canceling can be expected in the multiuser method than in the single user method because information (receive timings, levels, spreading codes) about a plurality of users is available although its hardware dimension and processing amount grow larger than in the single user method.

[0007] Fig. 1 is a block diagram showing a conventional CDMA receiver using the multiuser method. This receiver employs a decorrelator disclosed in R. Lupas and S. Verdu, "Near-Far Resistance of Multiuser Detectors in Asynchronous Channels", IEEE Trans. Com. vol. COM-38, No. 4 pp. 496-508, April 1990.

[0008] It is assumed in the receiver that the number of simultaneous users is K, the number of receiving paths of individual users are L_1, L_2, ...L_k, respectively, and the total number of all the receiving paths, that is, the total sum of L_1, L_2, ..., L_k is M.

[0009] The received signal is divided into M parts, and fed to despreading filters 11 (11-1 - 11-M) provided for individual paths of the users. A spreading code generator 10 refers to identification numbers of the users, and supplies spreading codes to respective despreading filters 11 and a cross-correlator 12.

[0010] The despreading filters 11 despread the received signal using filter coefficients based on the spreading codes supplied, and output information symbols and receive timing information. The cross-correlator 12, using the spreading codes from the spreading code generator 10 and receive timing information from the despreading filters 11, calculates cross-correlations between the spreading codes of all the paths, and feeds them to a decorrelator 15. The decorrelator 15 forms a correlation matrix, an array of cross-correlations supplied thereto, calculates an inverse matrix of the correlation matrix, and multiplies the inverse matrix by received signal vectors, thereby carrying out orthogonalization between the entire received signal vectors.

[0011] The signal vectors after the orthogonalization are RAKE combined by RAKE combiners 18 (18-1 - 18-K). That is, signals received from the entire paths of each users undergo phase correction, followed by weighted combining. The RAKE combined received signals undergo symbol decision by decision blocks 19 (19-1 -19-K). Thus, the received signals are decoded.

[0012] The decorrelator proposed by Verdu et al. assumes that the despreading codes are invariant for individual symbols, that is, the period of the spreading codes is identical to that of the symbols. However, a method is proposed for implementing a decorrelator for a system using middle codes or long codes, which are spreading codes with periods longer than that of symbols (International patent application WO95/29535 published 2 November 1995). According to this technique, the decorrelator can also be applied to a system using both long codes and short codes. In this specification, the term "short code" refers to a spreading code whose period is one symbol long, or 128 chip intervals or less in practice. The term "middle code" refers to a spreading code whose period is considerably longer than that of

symbols, ranging from more than processing gain to 10,000 symbol intervals. The term "long code" refers to a spreading code whose period is sufficiently longer than that of symbols, exceeding 10,000 symbol intervals. By using such codes in connection with the decorrelator makes orthogonalization possible on reverse channels within a cell in the CDMA cellular.

[0013] The conventional orthogonalization using the decorrelator, however, presents the following problems:

(1) When a great number of signal vectors are subject to the orthogonalization in the conventional method, characteristics of the orthogonalization is much degraded because its effect is canceled owing to noise enhancement. Furthermore, when the number of the signal vectors to be orthogonalized exceeds the processing gain, the orthogonalization itself becomes principally impossible.

Fig. 2 shows an increase of bit error rates obtained by computer simulation when the number of simultaneous users steps up such as 5, 10, 15, 20 and 25. The abscissas of the graph indicate energy per bit to noise spectral density Eb/No, and the ordinates represent average bit error rates. In the simulation, it is assumed that the processing gain Pg=31, and the primary and secondary modulations are both BPSK.

As is seen from this figure, as the number of the simultaneous users increases, the average bit error rates increase and the communication quality degrades. In addition, when the number of the simultaneous users exceeds the processing gain, no inverse matrix of the correlation matrix exists, and the orthogonalization processing becomes impossible.

Under multipath environments in particular, the number of signals to be orthogonalized exceeds the number of simultaneous users, and grows M-1, where M is the total number of the entire paths. As a result, the number of simultaneous users that can be orthogonalized is greatly reduced as the number of paths increases.

(2) Since the decorrelator 15 of the conventional receiver calculates the decorrelations in a batch mode, the dimension of the matrix grow large, and an amount of the calculation becomes huge, which presents another problem.

[0014] One aspect of the present invention provides a CDMA multiuser receiver and method which can implement effective orthogonalisation and reduce a processing amount.

[0015] In a first aspect of the present invention, there is provided a CDMA multiuser receiver for receiving signals transmitted from users through one or more paths, said signals comprising symbols spread by spectrum spreading using different spreading codes assigned to respective users, and for separating at least one of said received signals, said CDMA multiuser receiver comprising: despreaders for despreading said received signals by using spreading codes associated with the users, and for outputting receive timing information of said received signals on each of said paths; level detectors for detecting received signal levels of said received signals on said paths; cross-correlation calculation means for calculating for each of said paths cross-correlations between said spreading codes taking account of said receive timing information; selecting means for obtaining, for each of said paths, interference amounts from the other paths on the basis of said received signal levels and said cross-correlations between said spreading codes, and for selecting Ns paths in order of magnitude of said interference amounts, Ns being an integer greater than one; and decorrelators for obtaining despread outputs, from which interferences are cancelled, on the basis of received symbols and cross-correlations associated with said Ns paths selected.

[0016] The spreading codes may consist of short codes and long codes, the short codes each having a period equal to one symbol duration, and the long codes each having a period greater than 10,000 symbol intervals.

[0017] The spreading codes may consist of middle codes, the middle codes each having a period longer than one symbol period and shorter than 10,000 symbol intervals.

[0018] The spreading codes may consist of short codes whose period equals one symbol duration.

[0019] The spreading codes may consist of short codes whose period equals one symbol duration, and wherein different spreading code groups are used in different cells.

[0020] The interference amounts from other paths may be products of the received signal levels of other paths and cross-correlations between the spreading codes.

[0021] The decorrelators may be each provided for each of the paths.

[0022] The level detectors may detect levels of output signals of the despreaders.

[0023] The level detectors may detect levels of output signals of the decorrelators.

[0024] The CDMA multiuser receiver may further comprise channel estimation means connected to output terminals of the decorrelators for estimating phase fluctuations due to fading on the basis of pilot symbols of a known pattern, and wherein the level detectors detect levels of output signals of the channel estimation means.

[0025] The pilot symbols may be periodically inserted into information symbols.

[0026] The pilot symbols may be continuously transmitted through a dedicated channel.

[0027] In a second aspect of the present invention, there is provided a CDMA multiuser receiving method in a CDMA system in which a transmitter side assigns

different spreading codes to respective users, and transmits symbols of the users after spectrum spreading the symbols using the spreading codes associated with the users, and a receiver side receives signals transmitted from the users through one or more paths, and separates at least one of received signals, said CDMA multiuser receiver method comprising the steps of: despreading said received signals by using spreading codes associated with the users, and outputting receive timing information of said received signals on each of said paths; detecting received signal levels of said received signals on said paths; calculating for each of said paths cross-correlations between said spreading codes taking account of said receive timing information; obtaining, for each of said paths, interference amounts from the other paths on the basis of said received signal levels and said cross-correlations between said spreading codes; selecting Ns paths in order of magnitude of said interference amounts, Ns being an integer greater than one; and obtaining despread outputs, from which interferences are cancelled, on the basis of received symbols and cross-correlations associated with said Ns paths selected.

[0028] According to the present invention, the total of Ns paths are selected in order of magnitude of received signal levels and cross-correlations between the spreading codes of respective paths (in order of magnitude of products of the received signal levels and the cross-correlations, for example), and the orthogonalization of the received symbols are carried out on the basis of cross-correlations of the selected paths. In this way, the number of signals to be orthogonalized on the reverse channels in the CDMA can be effectively reduced. In the conventional system, the effect of the orthogonalization is canceled owing to the noise enhancement occurring when the number of the signal vectors to be orthogonalized is very large. In addition, the conventional system has a problem in that when the number of signal vectors to be orthogonalized exceeds the processing gain, the orthogonalization itself becomes impossible. In contrast, the present invention can implement an effective orthogonalization processing.

[0029] Furthermore, since an embodiment of the present invention is provided with small decorrelators for individual paths of the users instead of the conventional batch decorrelator, a processing amount for obtaining inverse matrices can be greatly reduced. For example, when the number of signals to be orthogonalized is not so high as exceeding the processing gain, the processing amount can be greatly reduced by allowing a little degradation of the characteristics.

[0030] Moreover, the accuracy of detection of the received signal levels can be improved by using signals after the interference cancellation.

[0031] Embodiments of the present invention will now be described with reference to the drawings, in which:

Fig. 1 is a block diagram showing a conventional CDMA receiver;
Fig. 2 is a graph illustrating characteristics of the conventional CDMA receiver;
Figs. 3A and 3B are block diagrams showing a first embodiment of a CDMA multiuser receiver in accordance with the present invention;
Fig. 4 is a block diagram showing a preliminary selector of the first embodiment;
Fig. 5A is a schematic diagram illustrating a frame format used in the first embodiment, in which pilot symbols are interleaved into information symbols;
Fig. 5B is a schematic diagram illustrating a frame format used in the first embodiment, which includes a channel dedicated to pilot symbols;
Fig. 6 is a schematic diagram illustrating a CDMA system using short codes in connection with long codes;
Fig. 7 is a schematic diagram illustrating a CDMA system using middle codes;
Fig. 8A is a block diagram showing a spreading code generator and a cross-correlator in a system using only short codes;
Fig. 8B is a block diagram showing a spreading code generator and a cross-correlator in a system using short codes in connection with long codes;
Fig. 8C is a block diagram showing a spreading code generator and a cross-correlator in a system using only middle codes;
Fig. 9 is a profile illustrating cross-correlation distribution in a CDMA system using short codes;
Fig. 10 is a profile illustrating cross-correlation distribution in a CDMA system using short codes in connection with long codes;
Fig. 11 is a profile illustrating cross-correlation distribution in a CDMA system using only middle codes;
Fig. 12 is a graph illustrating a processing amount per decorrelator in accordance with one embodiment of the present invention in comparison with that of the conventional example;
Fig. 13 is a graph for explaining improvement in a second embodiment; and
Figs. 14A and 14B are block diagrams showing the second embodiment of a CDMA multiuser receiver in accordance with the present invention.

EMBODIMENT 1

[0032] Figs. 3A and 3B are block diagrams showing a CDMA multiuser receiver in accordance with one embodiment of the present invention. In Figs. 3A and 3B, a spreading code generator 10 generates spreading codes assigned to individual users on the basis of identification numbers of users, and supplies the spreading codes to despreading filters 11. The spreading code generator 10 is implemented with a shift register for generating Gold codes or PN sequences. Alternatively, it can be realized with a fast readable semiconductor

memory such as a ROM or RAM which stores the entire spreading codes, in connection with an address converter for producing a memory address from the user identification numbers.

[0033] The despreading filters 11 (11-1 - 11-M) despread a received signal using filter coefficients based on spreading codes fed from the spreading code generator 10, and output received symbols (despread signals) and receive timing information for each path of each user. The received symbols and receive timing information are fed to a preliminary selector 20, and the receive timing information is fed to a cross-correlator 12. The despreading filters 11 can be implemented with matched filters or sliding correlators.

[0034] The cross-correlator 12 calculates cross-correlations between the entire paths of all the users by using receive timing information fed from the despreading filters 11 and the spreading codes assigned to the individual users. The cross-correlator 12 can be implemented with a correlator, for example. Alternatively, when the number of the spreading codes is rather small, it is possible to prestore cross-correlations in a memory, and output the cross-correlations by using the receive timing information fed from the despreading filters 11, and the spreading codes assigned to the individual users.

[0035] Level detectors 14 (14-1 - 14-M) are connected to respective output terminals of the despreading filters 11 to detect signal levels of the paths.

[0036] The preliminary selector 20 is supplied with the received symbols and the receive timing information from the despreading filters 11, and with the cross-correlations from the cross-correlator 12. In addition, it is supplied with the received signal levels from the level detectors 14 (14-1 - 14-M).

[0037] Fig. 4 is a block diagram showing elements per path (j-th path) of the preliminary selector 20. Similar elements are provided for the other paths. In this figure, the reference numerals 21 and 22 designate selectors. The selector 21 is supplied with (M-1) cross-correlations r_{j1}, r_{j2}, ... r_{jM} (excluding r_{jj}) per path from the cross-correlator 12. In other words, it is supplied with the cross-correlations between the j-th path and all the other paths. On the other hand, the selector 22 is provided with (M-1) received signal levels y_1, y_2, . . . y_M (except for y_j) per path from the level detectors 14. That is, the received signal levels of all the other paths are fed to the selector 22. The selectors 21 and 22 sequentially select one of the (M-1) cross-correlations and received signal levels, respectively, and feeds them to a multiplier 24. The multiplier 24 sequentially calculates products $r_{j1} \times y_1$, $r_{j2} \times y_2$, ... $r_{jM} \times y_M$, thereby outputting (M-1) products (interference amounts) of the cross-correlations and received signal levels for individual paths excluding the product of the j-th path. The results, which correspond to amounts of the interference to the j-th path from the other paths, are supplied to a selection block 25.

[0038] The selection block 25 selects Ns interference amounts from the (M-1) interference amounts. More specifically, it selects Ns interference amounts in order of magnitude, and supplies an exchanging block 26 with Ns indices indicating the paths associated with the selected interference amounts. The exchanging block 26 outputs cross-correlations between received symbols of the Ns paths and the j-th path.

[0039] Thus, Ns received symbols and Ns cross-correlations selected for each path are fed to a decorrelator 15-j (j = 1 - M) in Fig. 3B. The individual decorrelators 15 array the Ns received symbols fed from the preliminary selector 20 to form Ns-dimension received symbol vectors, and the Ns cross-correlations to form correlation matrices of a strap-like Hermitian matrix, and calculate the inverse matrices thereof. The decorrelators 15 further multiply the received symbol vectors by the inverse matrices to produce Ns-dimension vectors orthogonalized with each other, and supply them to channel estimators 16 (16-1 - 16-M). The decorrelators 15, whose main function is to calculate the inverse matrices, can be implemented with a DSP (Digital Signal Processor) or dedicated hardware such as a systolic array processor. In either case, a small size decorrelator can sufficiently achieve the function of the decorrelator 15 because it only handles Ns signals selected. A method for forming the correlation matrices by arraying the cross-correlations is disclosed in the S. Verdu et al. paper mentioned before.

[0040] The channel estimators 16 estimate phase fluctuations and amplitude fluctuations due to fading for each path of each user. Fig. 5A illustrates a frame format employed to estimate such fluctuations. A transmitter side periodically inserts known pilot symbols into information symbols as shown in this figure. The channel estimators 16, using the pilot symbols, estimates the phase fluctuations and amplitude fluctuations by absolute coherent detection using pilot interpolation. Specifically, the channel estimators 16 form information for correcting the phase and amplitude of information symbols by averaging the transfer functions of channels obtained from the pilot signals, and by interpolating the averaged values into the information symbol sections. The information for correction is fed to phase compensators 17 (17-1 - 17-M). The phase compensators 17 compensate the phase fluctuations of received symbols of respective paths by using the phase fluctuation estimation values due to fading fed from the channel estimators 16. The details of this processing are described in S. Sampei, "Rayleigh Fading Compensation for QAM in Land Mobile Radio Communications", IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 42, NO. 2, MAY 1993, and Sawahashi, et al. PCT/JP95/01252.

[0041] The pilot symbols may be transmitted continuously through a dedicated channel rather than inserting them into the information symbols, as shown in Fig. 5B. In this case, the phase and amplitude of the information symbols can be continuously compensated by using the phase and amplitude fluctuations of the pilot symbols

corresponding to the information symbols.

[0042] The phase compensated received symbols are subject to weighting combining by RAKE combiners 18 (18-1 - 18-K) provided for respective users. As weighting factors by which the signals of the paths are multiplied, SIRS (Signal-to-Interference Ratios) of the paths, the received signal levels of the paths after the interference cancellation, or estimated values of amplitude fluctuations of the paths due to fading can be employed. Among these, the weighting factors in proportion to the SIRs of the paths provide the maximal ratio combining. The RAKE combined signals are decided by decision blocks 19 (19-1 - 19-K), thereby recovering the information symbols.

[0043] When cellular mobile communications employ the CDMA, an identical spreading code cannot be assigned to a multiple users within a cell. The same spreading code can only be reused in cells separated apart by a repetition distance determined considering interference amounts. This means the following:

(1) Spreading code assignment management is necessary among a plurality of cells.
(2) Since the total number of assignable spreading codes per cell is less than the processing gain, the number of the simultaneous users is also less than that.

[0044] To overcome such shortages, systems are proposed in which short codes are used in connection with long codes or only middle codes are employed instead of short codes alone. The present invention can also be applied to such systems.

[0045] Fig. 6 is a schematic diagram showing a system employing the short codes in connection with the long codes. Individual cells use the same short code group A in connection with different long codes as spreading codes. By using the long codes with the short codes, the received signals from the other users are thoroughly made random and white. Thus assigning the different long codes to different cells makes it possible to use the same short code group in the individual cells. This will implement a management free system with regard to the spreading code assignment, thereby avoiding a decrease in the number of simultaneous users due to reduction in the assignable spreading codes. Furthermore, a further increase in capacity can be expected by reducing the interference between the users in the cell, that is, by carrying out the orthogonalization in the cell. The details of this are disclosed in Viterbi, A. M. and Viterbi, A. J., "Erlang Capacity of a power controlled CDMA system", IEEE J. Select. Area Commun. vol. 11, pp. 892-900, Aug. 1993.

[0046] Fig. 7 is a schematic diagram showing a system employing the middle codes alone. The length of the middle codes must be set rather long such that the probability that the same spreading code is assigned to a plurality of users is sufficiently low even if the same code group is used in adjacent cells as shown in this figure. Using the middle codes makes it possible to increase the total number of the spreading codes, and to ameliorate the acquisition delay involved in the synchronization when only the long codes are employed. Although code management among adjacent cells is necessary in the system employing the middle codes, reduction in the number of simultaneous users can be prevented because of the sufficient number of assignable spreading codes.

[0047] Figs. 8A - 8C are block diagrams showing configurations of the spreading code generator 10 and the cross-correlator 12 when only the short codes are used, short codes are used in connection with the long codes, and only the middle codes are used, respectively.

[0048] In the case where only the short codes are employed, the spreading code generator 10, which is provided with a short code generator 10A as shown in Fig. 8A, generates short codes corresponding to user identification numbers, and feeds them to the cross-correlator 12. The period of the short codes is 256 chip intervals at most, which corresponds to one symbol length. It is enough for the cross-correlator 12 to calculate the cross-correlations only when a user starts communications or a change in receiving timings (that is, relative delay times between multipaths) occurs.

[0049] In the case where the short codes are used in connection with the long codes, the spreading code generator 10 is provided with a short code generator 10A and a long code generator 10B. The short code generator 10A generates short codes corresponding to user identification numbers, and the long code generator 10B generates long codes corresponding to a base station identification number. This is because different long codes are assigned to different adjacent cells as shown in Fig. 6. The generated short codes and long codes are fed to an EXCLUSIVE OR circuit (EX-OR) 13, and its output is fed to the cross-correlator 12. Since the spreading code changes from symbol to symbol in this method, the cross-correlator 12 must calculate the cross-correlations for each symbol.

[0050] In the case where only the middle codes are employed, the spreading code generator 10 is provided with a middle code generator 10C as shown in Fig. 8C. The middle codes generated by the middle code generator 10C are fed to the cross-correlator 12. In this method, too, since the spreading code changes from symbol to symbol, the cross-correlator 12 must calculate the cross-correlations for each symbol.

[0051] The cross-correlator 12 calculates the cross-correlations between the entire paths of all the users on the basis of the spreading codes fed from the spreading code generator 10 and the receive timings fed from the despread filters 11, and supplies the preliminary selector 20 with the cross-correlations.

[0052] Fig. 9 shows distribution of the cross-correlations when different short code groups are used, Fig. 10 shows distribution of the cross-correlations when the

short codes are employed in connection with the long codes, and Fig. 11 shows the distribution of the cross-correlations when the middle codes are used.

[0053] In these graphs, the abscissas represent values of the cross-correlations relative to the peak of autocorrelation, that is, the interference levels in terms of dB, and the ordinates indicate the occurrence probabilities of the cross-correlations. In these cases, it is assumed that the processing gain Pg = 127, the short codes consist of Gold codes of seventh order, the long codes consist of PN sequences of 31-th order, and the middle code consist of Gold codes of 10-th order. Furthermore, it is assumed that the spreading codes and receive timings are random, and the number of trials is 100,000. In addition, the mean values of respective cases are shown in these figures.

[0054] As seen from Figs. 9 - 11, the occurrence probabilities of cross-correlations (interference levels) exceeding the average values are less than half of the entire frequencies. This means that effective cancellations can be achieved by selectively canceling the interferences of large cross-correlations in the orthogonalization processing.

[0055] Fig. 12 is a graph illustrating a processing amount per decorrelator, wherein the abscissas represent the number of signals fed to the decorrelator, and the ordinates represent the processing amount per decorrelator. The curve represents the processing amounts per decorrelator in accordance with one embodiment of the present invention, and the X mark indicates the processing amount per conventional decorrelator. Since the decorrelating operation consists of a calculation of an inverse matrix, its processing amount is proportional to the third power of the dimension of the correlation matrix. Consequently, the conventional decorrelator which performs orthogonalization of the entire received symbols in a batch mode becomes very difficult to be implemented as the number of users and paths increase. Furthermore, since it is difficult for the inverse matrix calculation to be handled by the parallel processing, hardware with parallel processing is difficult to realize. In contrast with this, since this embodiment of the present invention employs multiple small order decorrelators, the processing amount can be greatly reduce.

EMBODIMENT 2

[0056] In the first embodiment shown in Figs. 3A and 3B, the received signal levels are detected at the outputs of the despreading filters 11. This presents a problem in that the levels of a desired signal cannot be detected correctly when the interference level is high because of many simultaneous users.

[0057] Fig. 13 is a graph illustrating this problem, in which the fluctuations of the received signal level is shown under a fading environment. In this graph, solid lines represent level fluctuations of a desired signal, and dotted lines A and B indicate interference levels. Although the interference levels from the other users also fluctuate, they are averaged as A and B because they are independent fading. When the received signal level is sufficiently higher than the interference level as A, the amplitude fluctuations of the received signal substantially agree with the despread output level. The desired signal, however, may be buried in the interference if the received signal level is low in comparison with the interference level as B, in which case the amplitude fluctuations of the received signal cannot be correctly estimated at the despread output.

[0058] The second embodiment is proposed to solve such a problem. It will now be described with reference to Figs. 14A and 14B. The second embodiment differs from the first embodiment in the positions of the level detectors 14. Specifically, the input terminals of the level detectors 14 are connected to the output terminals of the channel estimators 16 in this embodiment. The level detectors 14 may be connected to the output terminals of the decorrelators 15.

[0059] According to this embodiment, the level detectors 14 carry out level detection based on the output signals from the decorrelators. These output signals differ from the output signals from the despeading filters in that they include no interference components due to cross-correlations between the spreading codes. As a result, highly accurate level detection is possible even if the interference level is as high as B in Fig. 13.

[0060] Furthermore, since the signal passing through the channel estimators 16 undergo the estimation of amplitude and phase fluctuations, the received signal levels can be estimated more accurately.

[0061] The present invention has been described in detail with respect to various embodiments, and it will now be apparent from the foregoing to those skilled in the art that changes and modifications may be made without departing from the scope of the invention as defined in the appended claims.

Claims

1. A CDMA multiuser receiver for receiving signals transmitted from users through one or more paths (2), said signals comprising symbols spread by spectrum spreading using different spreading codes assigned to respective users, and for separating at least one of said received signals, said CDMA multiuser receiver comprising:

   despreaders (11) for despreading said received signals by using spreading codes associated with the users, and for outputting receive timing information of said received signals on each of said paths;
   level detectors (14) for detecting received signal levels of said received signals on said

paths;
cross-correlation calculation means (12) for calculating for each of said paths cross-correlations between said spreading codes taking account of said receive timing information;
selecting means (20) for obtaining, for each of said paths, interference amounts from the other paths on the basis of said received signal levels and said cross-correlations between said spreading codes, and for selecting Ns paths in order of magnitude of said interference amounts, Ns being an integer greater than one; and
decorrelators (15) for obtaining despread outputs, from which interferences are cancelled, on the basis of received symbols and cross-correlations associated with said Ns paths selected.

2. The CDMA multiuser receiver as claimed in claim 1, wherein said receiver is operable to receive signals comprising symbols spread by spreading codes consisting of short codes and long codes, said short codes having a period equal to one symbol duration, and said long code having a period greater than 10,000 symbol intervals.

3. The CDMA multiuser receiver as claimed in claim 1, wherein said receiver is operable to receive signals comprising symbols spread by spreading codes consisting of middle codes, said middle codes having a period longer than one symbol period and shorter than 10,000 symbol intervals.

4. The CDMA multiuser receiver as claimed in claim 1, wherein said receiver is operable to receive signals comprising symbols spread by spreading codes consisting of short codes whose period equals one symbol duration.

5. The CDMA multiuser receiver as claimed in claim 1, wherein said receiver is operable to receive signals comprising symbols spread by spreading codes consisting of short codes whose period equals one symbol duration, and wherein different spreading code groups are used in different cells.

6. The CDMA multiuser receiver as claimed in any one of claims 1 to 5, wherein said selecting means (20) is operable to obtain said interference amounts from other paths as products of said received signal levels of other paths and cross-correlations between said spreading codes.

7. The CDMA multiuser receiver as claimed in any one of claims 1 to 6, wherein said decorrelators (15) are each provided for each of said paths.

8. The CDMA multiuser receiver as claimed in any one of claims 1 to 7, wherein said level detectors (14) are operable to detect levels of output signals of said despreaders (11).

9. The CDMA multiuser receiver as claimed in any one of claims 1 to 7, wherein said level detectors (14) are operable to detect levels of output signals of said decorrelators (15).

10. The CDMA multiuser receiver as claimed in claim 9, further comprising channel estimation means (16) connected to output terminals of said decorrelators (15) for estimating phase fluctuations due to fading on the basis of pilot symbols of a known pattern, and wherein said level detectors (14) are operable to detect levels of output signals of channel estimation means (16).

11. The CDMA multiuser receiver as claimed in claim 10, wherein said pilot symbols are periodically inserted into information symbols of said symbols of said received signals.

12. The CDMA multiuser receiver as claimed in claim 10, wherein said signals comprise a dedicated channel through which said pilot symbols are capable of being continuously transmitted.

13. A CDMA multiuser receiving method in a CDMA system in which a transmitter side assigns different spreading codes to respective users, and transmits symbols of the users after spectrum spreading the symbols using the spreading codes associated with the users, and a receiver side receives signals transmitted from the users through one or more paths, and separates at least one of received signals, said CDMA multiuser receiver method comprising the steps of:

despreading said received signals by using spreading codes associated with the users, and outputting receive timing information of said received signals on each of said paths;
detecting received signal levels of said received signals on said paths;
calculating for each of said paths cross-correlations between said spreading codes taking account of said receive timing information;
obtaining, for each of said paths, interference amounts from the other paths on the basis of said received signal levels and said cross-correlations between said spreading codes;
selecting Ns paths in order of magnitude of said interference amounts, Ns being an integer greater than one; and
obtaining despread outputs, from which interferences are cancelled, on the basis of received

symbols and cross-correlations associated with said Ns paths selected.

14. The CDMA multiuser receiving method as claimed in claim 13, wherein said receiving step comprises receiving signals comprising symbols spread by spreading codes consisting of short codes and long codes, said short codes having a period equal to one symbol duration and said long codes having a period greater than 10,000 symbol intervals.

15. The CDMA multiuser receiving method as claimed in claim 13, wherein said receiving step comprises receiving signals comprising symbols spread by spreading codes consisting of middle codes, said middle codes having a period longer than one symbol period and shorter than 10,000 symbol intervals.

16. The CDMA multiuser receiving method as claimed in claim 13, wherein said receiving step comprises receiving signals comprising symbols spread by spreading codes consisting of short codes whose period equals one symbol duration.

17. The CDMA multiuser receiving method as claimed in claim 13, wherein said receiving step comprises receiving signals comprising symbols spread by spreading codes consisting of short codes whose period equals one symbol duration, and wherein different spreading code groups are used in different cells.

18. The CDMA multiuser receiving method as claimed in any one of claims 13 to 17, wherein said interference amount obtaining step comprises obtaining said interference amount as products of said received signal levels of other paths and cross correlations between said spreading codes.

19. The CDMA multiuser receiving method as claimed in any one of claims 13 to 18, wherein said despread output obtaining step comprises obtaining one despread output for each of said paths.

20. The CDMA multiuser receiving method as claimed in any one of claims 13 to 19, wherein said detecting step comprises detecting the received signal levels from the despread received signals.

21. The CDMA multiuser receiving method as claimed in any one of claims 13 to 19, wherein said detecting step comprises detecting the received signal levels from the despread outputs.

22. The CDMA multiuser receiving method as claimed in claim 21 further including the steps of estimating phase fluctuations due to fading on the basis of pilot symbols of a known pattern, and detecting levels of output signals of channel estimations.

23. The CDMA multiuser receiving as claimed in claim 22, wherein said pilot symbols are periodically inserted into information symbols.

24. The CDMA multiuser receiving method as claimed in claim 22, wherein said pilot symbols are continuously transmitted through a dedicated channel.

Patentansprüche

1. CDMA-Mehrfachbenutzerempfangseinrichtung zum Empfang von Signalen, die von Benutzern durch einen oder mehr Pfade (2) übertragen werden, wobei die Signale Symbole umfassen, die durch einen Spektrumspreizvorgang unter Verwendung von jeweiligen Benutzern zugewiesenen verschiedenen Spreizcodes gespreizt wurden, und zum Separieren von zumindest einem der empfangenen Signale, die CDMA-Mehrfachbenutzerempfangseinrichtung umfasst dabei:

   Entspreizungseinrichtungen (11) zum Entspreizen der empfangenen Signale unter Verwendung von mit den Benutzern verbundenen Spreizcodes und zum Ausgeben von Empfangszeitinformationen über die empfangenen Signale auf jedem der Pfade;
   Pegelerfassungseinrichtungen (14) zum Erfassen von empfangenen Signalpegeln von den empfangenen Signalen auf den Pfaden;
   eine Kreuzkorrelationsberechnungseinrichtung (12) zum Berechnen von Kreuzkorrelationen zwischen den Spreizcodes für jeden der Pfade, wobei die Empfangszeitinformationen in Betracht gezogen werden;
   eine Auswahleinrichtung (20) für den Erhalt von Interferenzmengen für jeden der Pfade von den anderen Pfaden auf der Grundlage der empfangenen Signalpegel und der Kreuzkorrelationen zwischen den Spreizcodes, und zum Auswählen von Ns-Pfaden in der Reihenfolge der Größenordnung der Interferenzmengen, wobei Ns eine Ganze Zahl größer Eins ist; und
   Entkorrelationseinrichtungen (15) für den Erhalt von entspreizten Ausgaben, aus denen die Interferenzen entfernt wurden, auf der Grundlage von empfangenen Symbolen und mit den ausgewählten Ns-Pfaden verbundenen Kreuzkorrelationen.

2. CDMA-Mehrfachbenutzerempfangseinrichtung nach Anspruch 1, wobei die Empfangseinrichtung für den Empfang von Signalen mit Symbolen betrieben werden kann, welche durch aus Kurzcodes und Langcodes bestehenden Spreizcodes gespreizt

wurden, dabei weisen die Kurzcodes eine einer Symboldauer gleiche Periode auf, und die Langcodes weisen eine Periode auf, die größer als 10.000 Symbolintervalle ist.

3. CDMA-Mehrfachbenutzerempfangseinrichtung nach Anspruch 1, wobei die Empfangseinrichtung für den Empfang von Signalen mit Symbolen betrieben werden kann, welche durch aus Mittelcodes bestehenden Spreizcodes gespreizt wurden, dabei weisen die Mittelcodes eine Periode auf, die länger als eine Symbolperiode und kürzer als 10.000 Symbolintervalle ist.

4. CDMA-Mehrfachbenutzerempfangseinrichtung nach Anspruch 1, wobei die Empfangseinrichtung für den Empfang von Signalen mit Symbolen betrieben werden kann, welche durch aus Kurzcodes bestehenden Spreizcodes gespreizt wurden, deren Periode gleich einer Symboldauer ist.

5. CDMA-Mehrfachbenutzerempfangseinrichtung nach Anspruch 1, wobei die Empfangseinrichtung für den Empfang von Signalen mit Symbolen betrieben werden kann, welche durch aus Kurzcodes bestehenden Spreizcodes gespreizt wurden, deren Periode gleich einer Symboldauer ist, und wobei verschiedene Spreizcodegruppen bei verschiedenen Zellen verwendet werden.

6. CDMA-Mehrfachbenutzerempfangseinrichtung nach einem der Ansprüche 1 bis 5, wobei die Auswahleinrichtung (20) für den Erhalt der Interferenzmengen von anderen Pfaden als Produkte der empfangenen Signalpegel von anderen Pfaden und Kreuzkorrelationen zwischen den Spreizcodes betrieben werden kann.

7. CDMA-Mehrfachbenutzerempfangseinrichtung nach einem der Ansprüche 1 bis 6, wobei die Entkorrelationseinrichtungen (15) jeweils für jeden der Pfade bereitgestellt sind.

8. CDMA-Mehrfachbenutzerempfangseinrichtung nach einem der Ansprüche 1 bis 7, wobei die Pegelerfassungseinrichtungen (14) zum Erfassen von Pegeln von Ausgangssignalen der Entspreizungseinrichtungen (11) betrieben werden können.

9. CDMA-Mehrfachbenutzerempfangseinrichtung nach einem der Ansprüche 1 bis 7, wobei die Pegelerfassungseinrichtungen (14) zum Erfassen von Pegeln von Ausgangssignalen der Entkorrelationseinrichtungen (15) betrieben werden können.

10. CDMA-Mehrfachbenutzerempfangseinrichtung nach Anspruch 9, ferner mit Kanalabschätzungseinrichtungen (16), die mit Ausgangsanschlüssen der Entkorrelationseinrichtungen (15) verbunden sind, um Phasenfluktuationen aufgrund von Schwund auf der Grundlage von Pilotsymbolen eines bekannten Musters abzuschätzen, und wobei die Pegelerfassungseinrichtungen (14) zum Erfassen von Pegeln von Ausgangssignalen der Kanalabschätzungseinrichtungen (16) betrieben werden können.

11. CDMA-Mehrfachbenutzerempfangseinrichtung nach Anspruch 10, wobei die Pilotsymbole in Informationssymbole der Symbole der empfangenen Signale periodisch eingesetzt werden.

12. CDMA-Mehrfachbenutzerempfangseinrichtung nach Anspruch 10, wobei die Signale einen dedizierten Kanal aufweisen, durch den die Pilotsymbole kontinuierlich übertragen werden können.

13. CDMA-Mehrfachbenutzerempfangsverfahren in einem CDMA-System, bei dem die Übertragungsseite an jeweilige Benutzer verschiedene Spreizcodes zuweist, und Symbole der Benutzer nach einem Spektrumsspreizen der Symbole unter Verwendung von den mit den Benutzern verbundenen Spreizcodes überträgt, und eine Empfängerseite Signale empfängt, die von Benutzern durch einen oder mehr Pfade übertragen werden, und zumindest eines der empfangenen Signale separiert, das CDMA-Mehrfachbenutzerempfangsverfahren umfasst dabei die Schritte:

Entspreizen der empfangenen Signale unter Verwendung von mit den Benutzern verbundenen Spreizcodes und Ausgeben von Empfangszeitinformationen über die empfangenen Signale auf jedem der Pfade;
Erfassen von empfangenen Signalpegeln von den empfangenen Signalen auf den Pfaden;
Berechnen von Kreuzkorrelationen zwischen den Spreizcodes für jeden der Pfade, wobei die Empfangszeitinformationen in Betracht gezogen werden;
Erhalten von Interferenzmengen für jeden der Pfade von den anderen Pfaden auf der Grundlage der empfangenen Signalpegel und der Kreuzkorrelationen zwischen den Spreizcodes,
Auswählen von Ns-Pfaden in der Reihenfolge der Größenordnung der Interferenzmengen, wobei Ns eine Ganze Zahl größer Eins ist; und
Erhalten von entspreizten Ausgaben, aus denen die Interferenzen entfernt wurden, auf der Grundlage von empfangenen Symbolen und mit den ausgewählten Ns-Pfaden verbundenen Kreuzkorrelationen.

14. CDMA-Mehrfachbenutzerempfangsverfahren nach

Anspruch 13, wobei der Empfangsschritt den Empfang von Signalen mit Symbolen umfasst, welche durch aus Kurzcodes und Langcodes bestehenden Spreizcodes gespreizt wurden, dabei weisen die Kurzcodes eine einer Symboldauer gleiche Periode auf, und die Langcodes weisen eine Periode auf, die größer als 10.000 Symbolintervalle ist.

15. CDMA-Mehrfachbenutzerempfangsverfahren nach Anspruch 13, wobei der Empfangsschritt den Empfang von Signalen mit Symbolen umfasst, welche durch aus Mittelcodes bestehenden Spreizcodes gespreizt wurden, dabei weisen die Mittelcodes eine Periode auf, die länger als eine Symbolperiode und kürzer als 10.000 Symbolintervalle ist.

16. CDMA-Mehrfachbenutzerempfangsverfahren nach Anspruch 13, wobei der Empfangsschritt den Empfang von Signalen mit Symbolen umfasst, welche durch aus Kurzcodes bestehenden Spreizcodes gespreizt wurden, deren Periode gleich einer Symboldauer ist.

17. CDMA-Mehrfachbenutzerempfangsverfahren nach Anspruch 13, wobei der Empfangsschritt den Empfang von Signalen mit Symbolen umfasst, welche durch aus Kurzcodes bestehenden Spreizcodes gespreizt wurden, deren Periode gleich einer Symboldauer ist, und wobei verschiedene Spreizcodegruppen bei verschiedenen Zellen verwendet werden.

18. CDMA-Mehrfachbenutzerempfangsverfahren nach einem der Ansprüche 13 bis 17, wobei der Schritt zum Erhalten der Interferenzmengen den Erhalt der Interferenzmengen als Produkte der empfangenen Signalpegel von anderen Pfaden und Kreuzkorrelationen zwischen den Spreizcodes umfasst.

19. CDMA-Mehrfachbenutzerempfangsverfahren nach einem der Ansprüche 13 bis 18, wobei der Schritt für den Erhalt einer entspreizten Ausgabe den Erhalt von einer entspreizten Ausgabe für jeden der Pfade umfasst.

20. CDMA-Mehrfachbenutzerempfangsverfahren nach einem der Ansprüche 13 bis 19, wobei der Erfassungsschritt das Erfassen der empfangenen Signalpegel von den entspreizten empfangenen Signalen umfasst.

21. CDMA-Mehrfachbenutzerempfangsverfahren nach einem der Ansprüche 13 bis 19, wobei der Erfassungsschritt das Erfassen der empfangenen Signalpegel von den entspreizten Ausgaben umfasst.

22. CDMA-Mehrfachbenutzerempfangsverfahren nach Anspruch 21, ferner mit den Schritten Abschätzen von Phasenfluktuationen aufgrund von Schwund auf der Grundlage von Pilotsymbolen eines bekannten Musters, und Erfassen von Pegeln von Ausgangssignalen von Kanalabschätzungen.

23. CDMA-Mehrfachbenutzerempfangsverfahren nach Anspruch 22, wobei die Pilotsymbole periodisch in die Informationssymbole eingesetzt werden.

24. CDMA-Mehrfachbenutzerempfangsverfahren nach Anspruch 22, wobei die Pilotsymbole kontinuierlich durch einen dedizierten Kanal übertragen werden.

Revendications

1. Récepteur AMRC multi-utilisateur pour recevoir des signaux émis par des utilisateurs sur un ou plusieurs chemins (2), ces signaux comprenant des symboles étalés par étalement de spectre en utilisant différents codes d'étalement assignés à des utilisateurs respectifs, et pour séparer l'un au moins des signaux reçus, ce récepteur AMRC multi-utilisateur comprenant :

   des dispositifs de désétalement (11) pour désétaler les signaux reçus en utilisant des codes d'étalement associés aux utilisateurs, et pour fournir en sortie une information temporelle de réception des signaux reçus sur chacun des chemins;
   des détecteurs de niveau (14) pour détecter des niveaux de signaux reçus pour les signaux reçus sur les chemins;
   des moyens de calcul d'inter-corrélation (12) pour calculer pour chacun des chemins des inter-corrélations entre des codes d'étalement, en tenant compte de l'information temporelle de réception;
   des moyens de sélection (20) pour obtenir, pour chacun des chemins, des valeurs de brouillage par les autres chemins sur la base des niveaux de signal reçu et des inter-corrélations entre les codes d'étalement, et pour sélectionner Ns voies en ordre de grandeur des valeurs de brouillage, Ns étant un entier supérieur à un; et
   des décorrélateurs (15) pour obtenir des signaux de sortie désétalés, dans lesquels des brouillages sont annulés, sur la base de symboles reçus et d'intercorrélations associées aux Ns voies sélectionnées.

2. Récepteur AMRC multi-utilisateur selon la revendication 1, ce récepteur pouvant être employé pour recevoir des signaux comprenant des symboles étalés par des codes d'étalement consistant en codes courts et en codes longs, les codes courts ayant une période égale à une durée de symbole, et les

codes longs ayant une période supérieure à 10000 intervalles de symbole.

3. Récepteur AMRC multi-utilisateur selon la revendication 1, ce récepteur pouvant être employé pour recevoir des signaux comprenant des symboles étalés par des codes d'étalement consistant en codes intermédiaires, ces codes intermédiaires ayant une période supérieure à une période de symbole et plus courte que 10000 intervalles de symbole.

4. Récepteur AMRC multi-utilisateur selon la revendication 1, ce récepteur pouvant être employé pour recevoir des signaux comprenant des symboles étalés par des codes d'étalement consistant en codes courts dont la période est égale à une durée de symbole.

5. Récepteur AMRC multi-utilisateur selon la revendication 1, ce récepteur pouvant être employé pour recevoir des signaux comprenant des symboles étalés par des codes d'étalement consistant en codes courts dont la période est égale à une durée de symbole, et différents groupes de codes d'étalement étant utilisés dans différentes cellules.

6. Récepteur AMRC multi-utilisateur selon l'une quelconque des revendications 1 à 5, dans lequel les moyens de sélection (20) peuvent être employés pour obtenir les valeurs de brouillage à partir d'autres chemins sous la forme de produits des niveaux de signal reçu d'autres chemins et d'inter-corrélations entre les codes d'étalement.

7. Récepteur AMRC multi-utilisateur selon l'une quelconque des revendications 1 à 6, dans lequel les décorrélateurs (15) sont respectivement incorporés pour chacun des chemins.

8. Récepteur AMRC multi-utilisateur selon l'une quelconque des revendications 1 à 7, dans lequel les détecteurs de niveau (14) peuvent être employés pour détecter des niveaux de signaux de sortie des dispositifs de désétalement (11).

9. Récepteur AMRC multi-utilisateur selon l'une quelconque des revendications 1 à 7, dans lequel les détecteurs de niveau (14) peuvent être employés pour détecter des niveaux de signaux de sortie des décorrélateurs (15).

10. Récepteur AMRC multi-utilisateur selon la revendication 9, comprenant en outre des moyens d'estimation de canal (16) connectés à des bornes de sortie des décorrélateurs (15) pour estimer des fluctuations de phase dues à l'évanouissement, sur la base de symboles pilotes d'une configuration connue, et dans lequel les détecteurs de niveau (14) peuvent être employés pour détecter des niveaux de signaux de sortie des moyens d'estimation de canal (16).

11. Récepteur AMRC multi-utilisateur selon la revendication 10, dans lequel les symboles pilotes sont insérés périodiquement dans des symboles d'information des symboles des signaux reçus.

12. Récepteur AMRC multi-utilisateur selon la revendication 10, dans lequel les signaux comprennent un canal spécialisé par lequel les symboles pilotes peuvent être transmis de façon continue.

13. Procédé de réception AMRC multi-utilisateur dans un système AMRC dans lequel un côté émetteur assigne différents codes d'étalement à des utilisateurs respectifs, et émet des symboles des utilisateurs après avoir soumis les symboles à un étalement de spectre en utilisant les codes d'étalement associés aux utilisateurs, et un côté récepteur reçoit des signaux émis par les utilisateurs sur un ou plusieurs chemins, et sépare l'un au moins des signaux reçus, ce procédé de réception AMRC multi-utilisateur comprenant les étapes suivantes :

   on désétale les signaux reçus en utilisant des codes d'étalement associés aux utilisateurs, et on fournit en sortie une information temporelle de réception des signaux reçus sur chacun des chemins;
   on détecte des niveaux de signal reçu pour les signaux reçus sur les chemins;
   on calcule pour chacun des chemins des inter-corrélations entre des codes d'étalement, en tenant compte de l'information temporelle de réception;
   on obtient, pour chacun des chemins, des valeurs de brouillage par les autres chemins sur la base des niveaux de signal reçu et des inter-corrélations entre les codes d'étalement;
   on sélectionne Ns chemins en ordre de grandeur des valeurs de brouillage, Ns étant un entier supérieur à un; et
   on obtient des signaux de sortie désétalés, desquels des brouillages sont annulés, sur la base de symboles reçus et d'inter-corrélations associées aux Ns chemins sélectionnés.

14. Procédé de réception AMRC multi-utilisateur selon la revendication 13, dans lequel l'étape de réception comprend la réception de signaux comprenant des symboles étalés par des codes d'étalement consistant en codes courts et en codes longs, les codes courts ayant une période égale à une durée de symbole et les codes longs ayant une période supérieure à 10000 intervalles de symbole.

15. Procédé de réception AMRC multi-utilisateur selon la revendication 13, dans lequel l'étape de réception comprend la réception de signaux comprenant des symboles étalés par des codes d'étalement consistant en codes intermédiaires, ces codes intermédiaires ayant une période plus longue qu'une période de symbole et plus courte que 10000 intervalles de symbole.

16. Procédé de réception AMRC multi-utilisateur selon la revendication 13, dans lequel l'étape de réception comprend la réception de signaux comprenant des symboles étalés par des codes d'étalement consistant en codes courts dont la période est égale à une durée de symbole.

17. Procédé de réception AMRC multi-utilisateur selon la revendication 13, dans lequel l'étape de réception comprend la réception de signaux comprenant des symboles étalés par des codes d'étalement consistant en codes courts dont la période est égale à une durée de symbole, et dans lequel différents groupes de codes d'étalement sont utilisés dans différentes cellules.

18. Procédé de réception AMRC multi-utilisateur selon l'une quelconque des revendications 13 à 17, dans lequel l'étape d'obtention de valeur de brouillage comprend l'obtention de la valeur de brouillage sous la forme de produits des niveaux de signal reçu d'autres chemins et d'inter-corrélations entre les codes d'étalement.

19. Procédé de réception AMRC multi-utilisateur selon l'une quelconque des revendications 13 à 18, dans lequel l'étape d'obtention de signaux de sortie désétalés comprend l'obtention d'un signal de sortie désétalé pour chacun des chemins.

20. Procédé de réception AMRC multi-utilisateur selon l'une quelconque des revendications 13 à 19, dans lequel l'étape de détection comprend la détection des niveaux de signal reçu à partir des signaux reçus désétalés.

21. Procédé de réception AMRC multi-utilisateur selon l'une quelconque des revendications 13 à 19, dans lequel l'étape de détection comprend la détection des niveaux de signal reçu à partir des signaux de sortie désétalés.

22. Procédé de réception AMRC multi-utilisateur selon la revendication 21, comprenant en outre les étapes consistant à estimer des fluctuations de phase dues à l'évanouissement, sur la base de symboles pilotes d'une configuration connue, et à détecter des niveaux de signaux de sortie d'estimations de canal.

23. Procédé de réception AMRC multi-utilisateur selon la revendication 22, dans lequel les symboles pilotes sont insérés périodiquement dans des symboles d'information.

24. Procédé de réception AMRC multi-utilisateur selon la revendication 22, dans lequel les symboles pilotes sont transmis continuellement par un canal spécialisé.

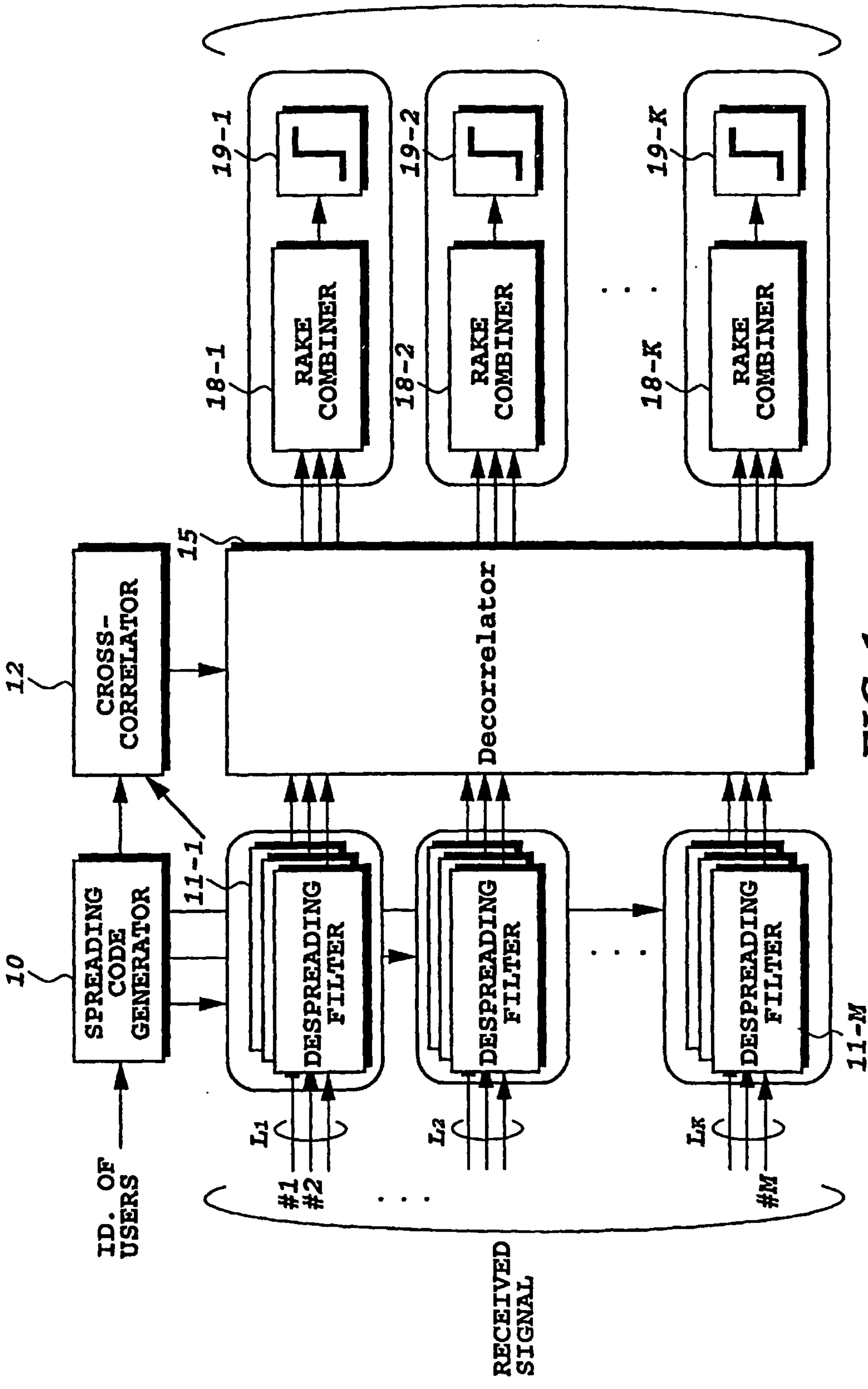


FIG.1
(PRIOR ART)

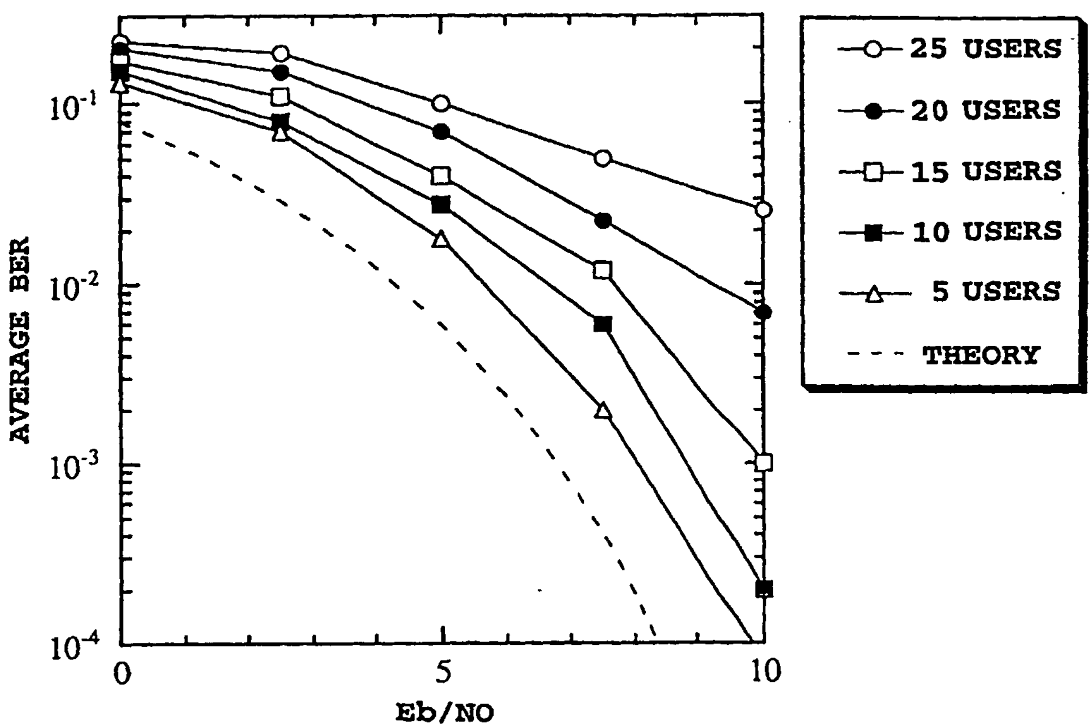


FIG. 2
(PRIOR ART)

FIG.3

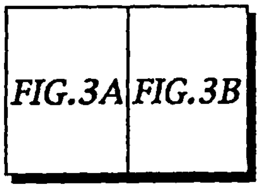


FIG.3A
FIG.3B

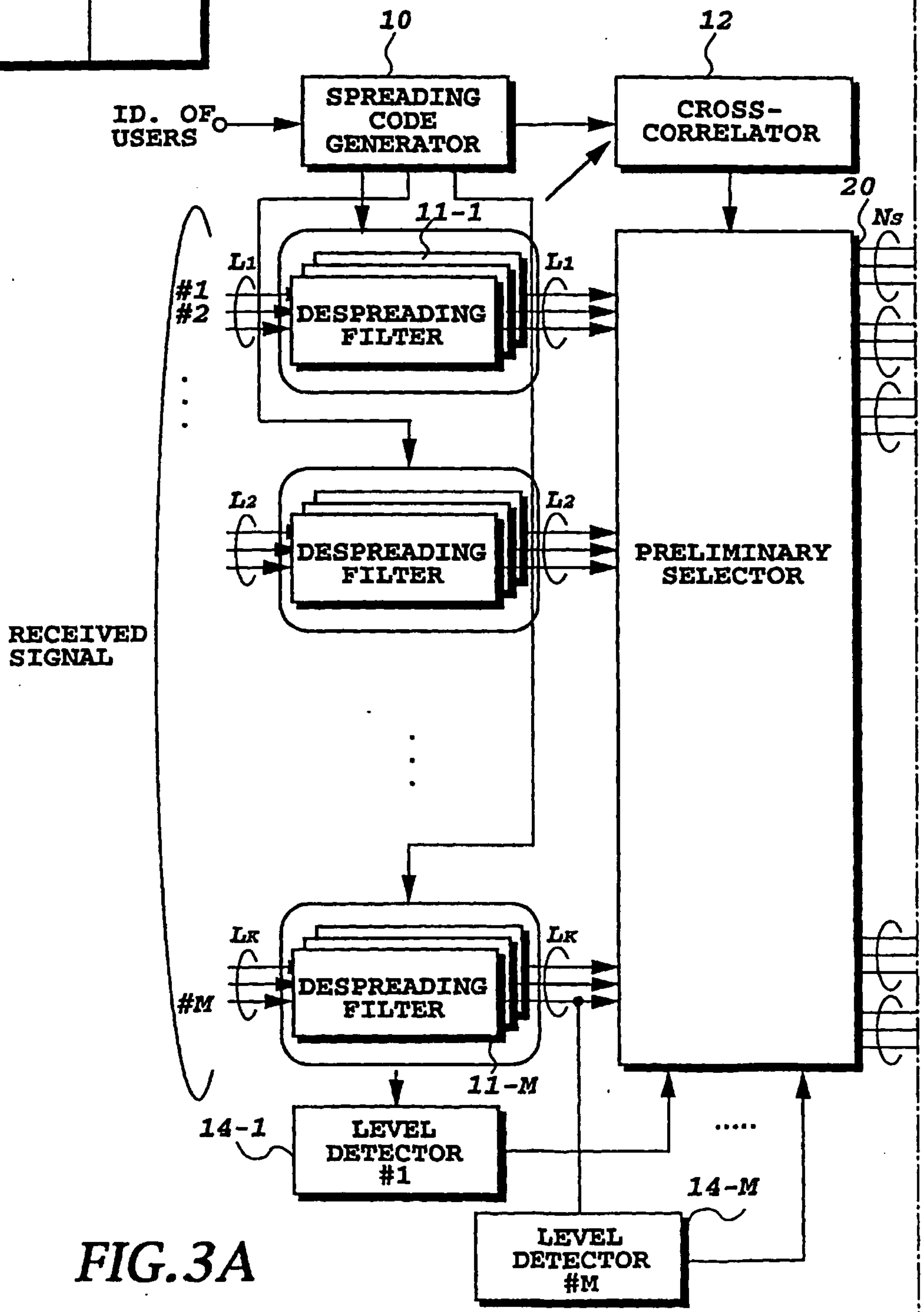

10
12
ID. OF USERS
SPREADING CODE GENERATOR
CROSS-CORRELATOR
20
Ns
11-1
L1
L1
#1
#2
DESPREADING FILTER
L2
L2
DESPREADING FILTER
PRELIMINARY SELECTOR
RECEIVED SIGNAL
LK
LK
#M
DESPREADING FILTER
11-M
14-1
LEVEL DETECTOR #1
14-M
LEVEL DETECTOR #M

FIG.3A

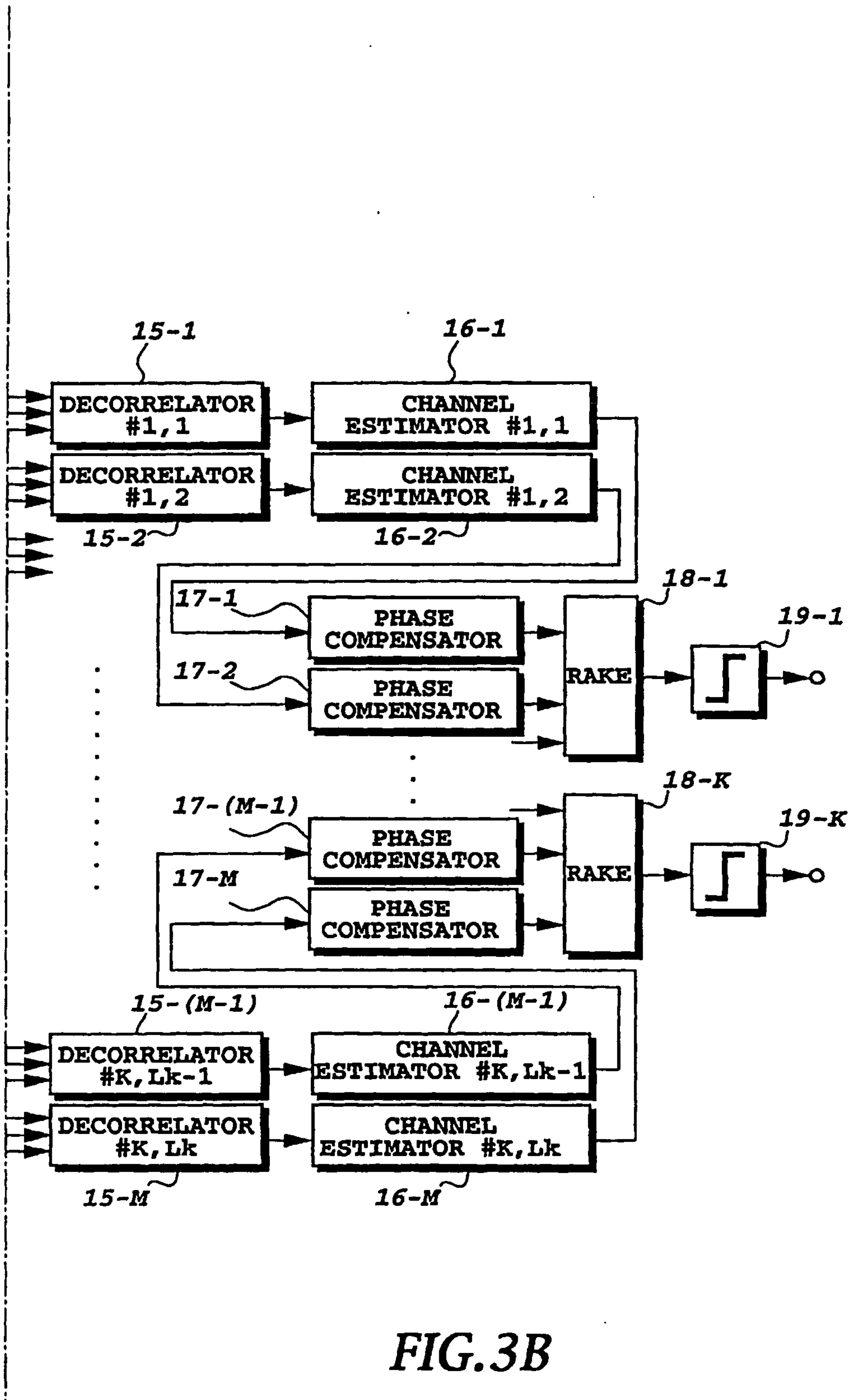

15-1
16-1
DECORRELATOR #1,1
CHANNEL ESTIMATOR #1,1
DECORRELATOR #1,2
CHANNEL ESTIMATOR #1,2
15-2
16-2
18-1
17-1
PHASE COMPENSATOR
19-1
17-2
PHASE COMPENSATOR
RAKE
18-K
17-(M-1)
PHASE COMPENSATOR
19-K
17-M
RAKE
PHASE COMPENSATOR
15-(M-1)
16-(M-1)
DECORRELATOR #K,Lk-1
CHANNEL ESTIMATOR #K,Lk-1
DECORRELATOR #K,Lk
CHANNEL ESTIMATOR #K,Lk
15-M
16-M

FIG.3B

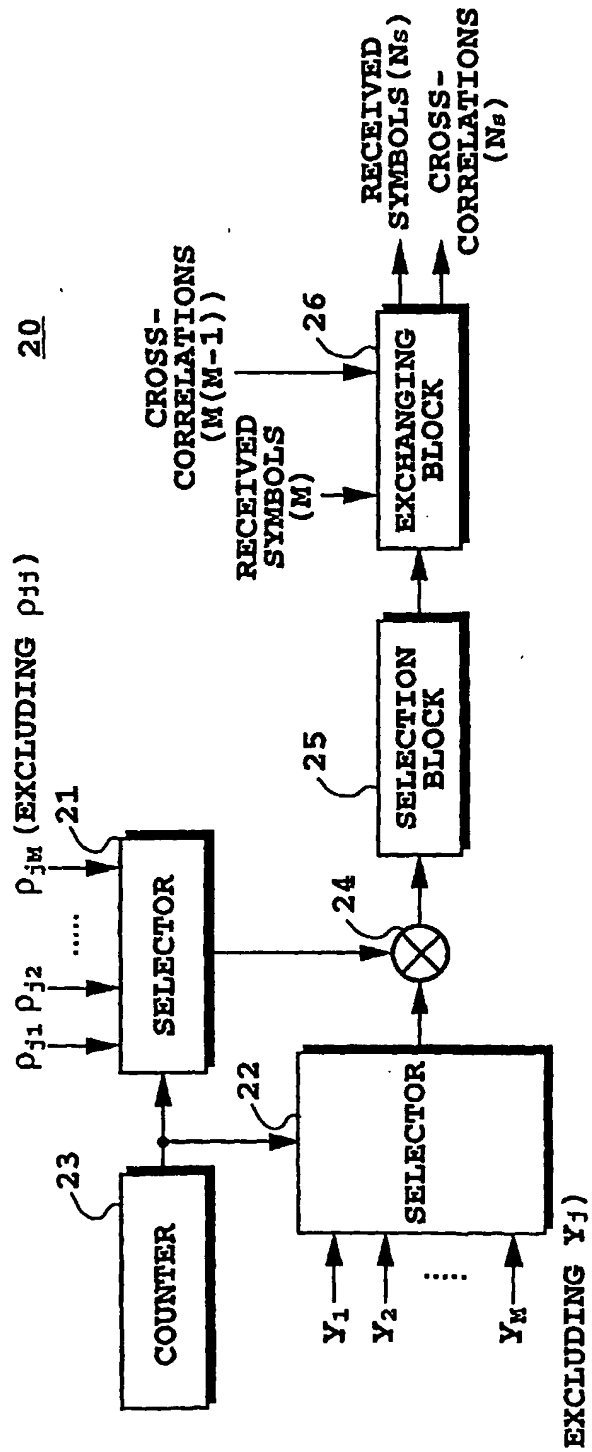

20
COUNTER
23
SELECTOR
21
22
ρ_{j1} ρ_{j2} ..... ρ_{jM} (EXCLUDING ρ_{jj})
SELECTOR
Y_1 Y_2 ..... Y_M
(EXCLUDING Y_j)
24
25
SELECTION BLOCK
26
EXCHANGING BLOCK
RECEIVED SYMBOLS (M)
CROSS-CORRELATIONS (M(M-1))
RECEIVED SYMBOLS (N_s)
CROSS-CORRELATIONS (N_s)

FIG.4

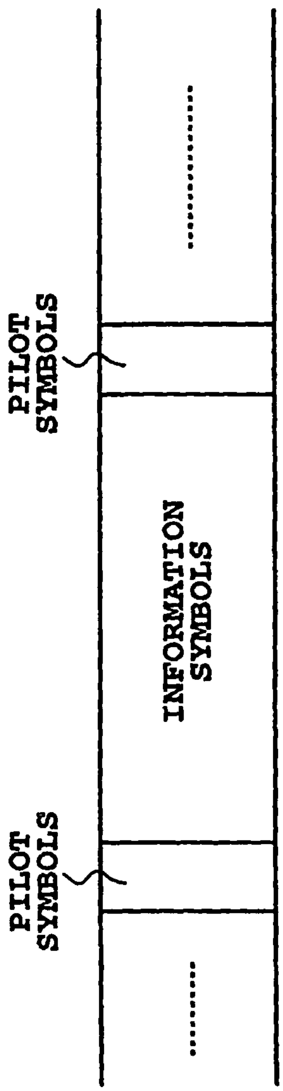


FIG.5A

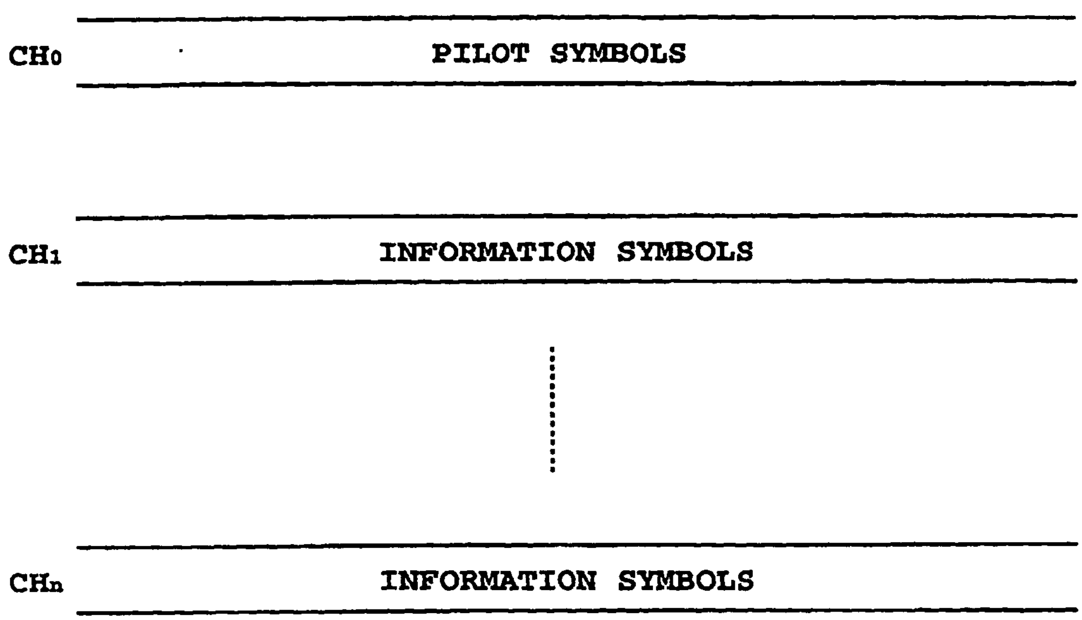

CH0
PILOT SYMBOLS
CH1
INFORMATION SYMBOLS
CHn
INFORMATION SYMBOLS

FIG.5B

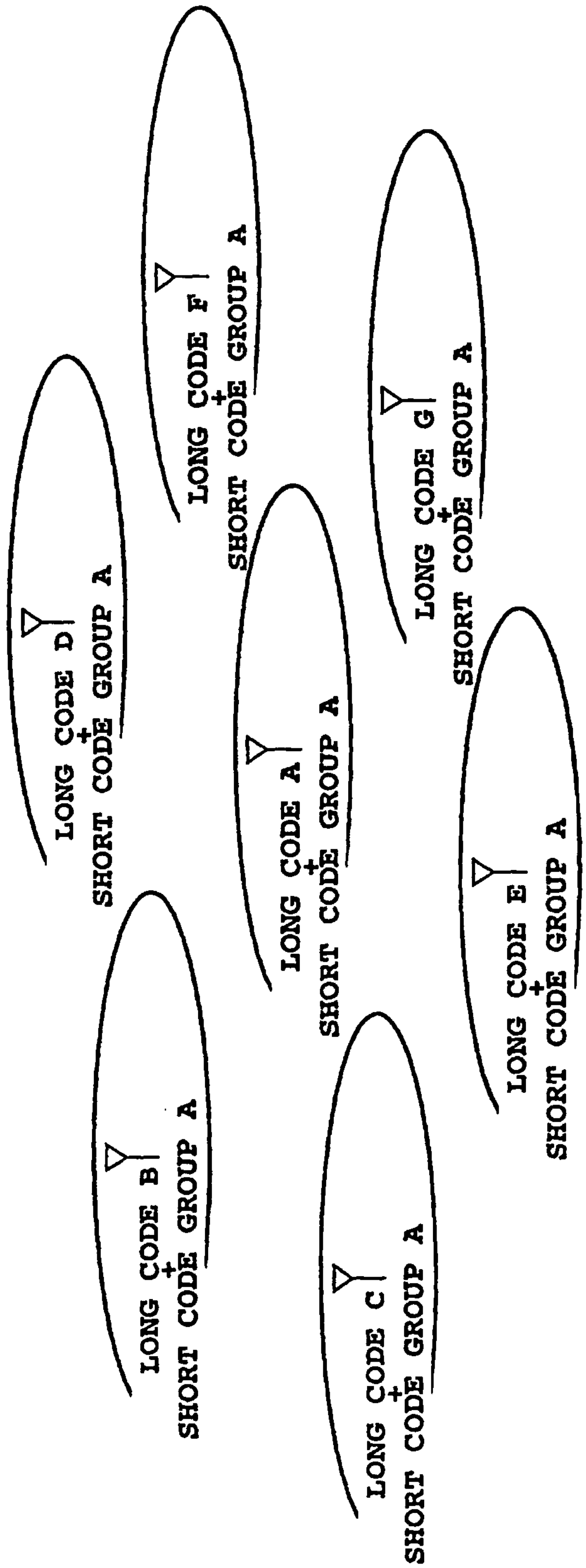

LONG CODE A
+
SHORT CODE GROUP A
LONG CODE B
+
SHORT CODE GROUP A
LONG CODE C
+
SHORT CODE GROUP A
LONG CODE D
+
SHORT CODE GROUP A
LONG CODE E
+
SHORT CODE GROUP A
LONG CODE F
+
SHORT CODE GROUP A
LONG CODE G
+
SHORT CODE GROUP A

FIG.6

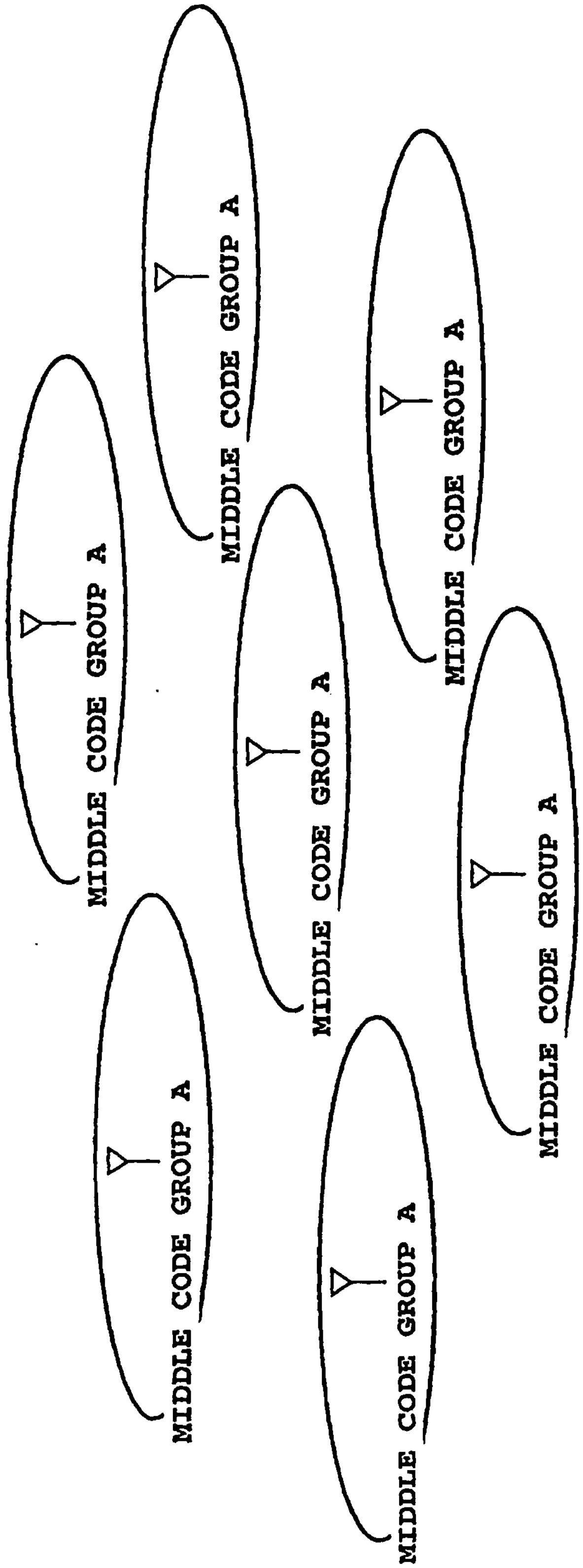

MIDDLE CODE GROUP A
MIDDLE CODE GROUP A
MIDDLE CODE GROUP A
MIDDLE CODE GROUP A
MIDDLE CODE GROUP A
MIDDLE CODE GROUP A
MIDDLE CODE GROUP A

FIG. 7

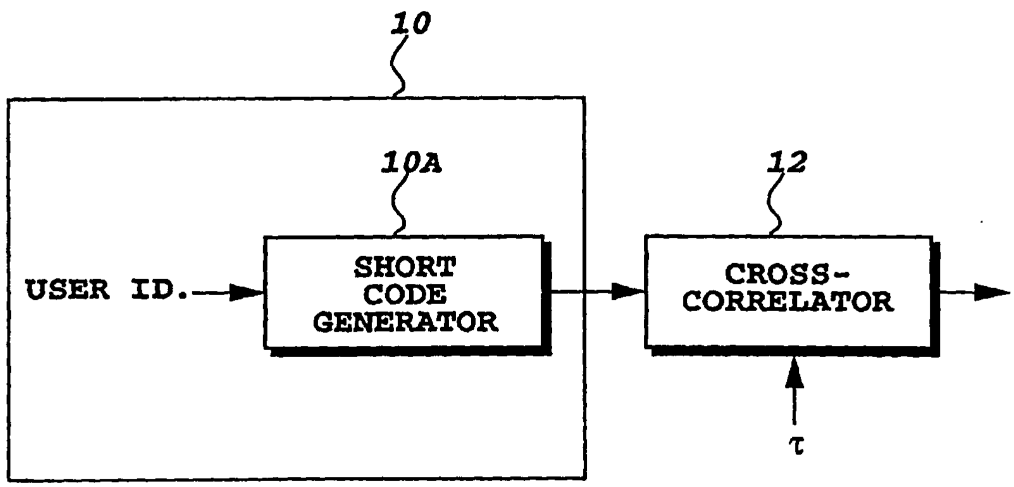


FIG.8A

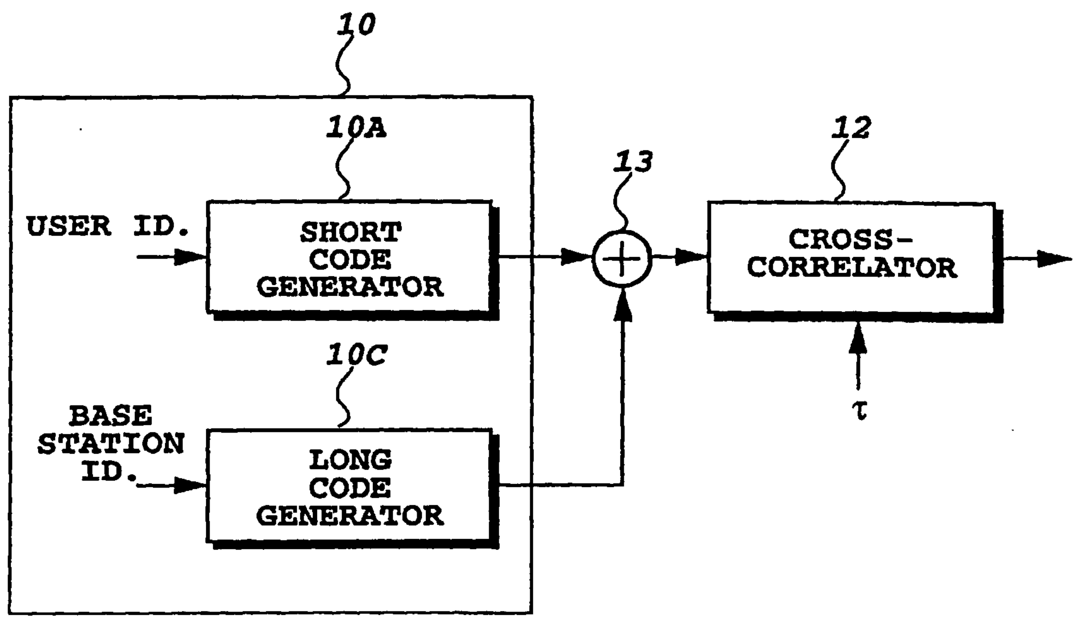

10
10A
USER ID.
SHORT CODE GENERATOR
10C
BASE STATION ID.
LONG CODE GENERATOR
13
12
CROSS-CORRELATOR
τ

FIG.8B

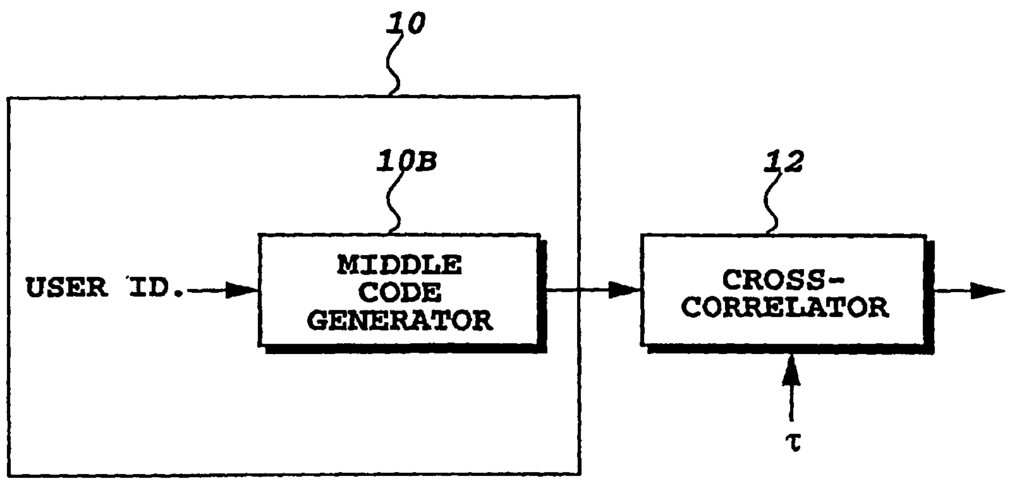


FIG.8C

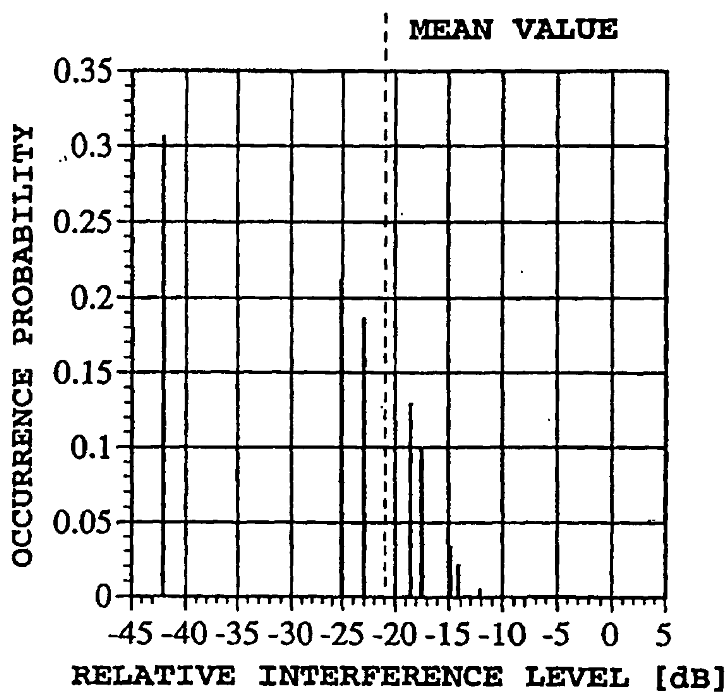

MEAN VALUE
OCCURRENCE PROBABILITY
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-45 -40 -35 -30 -25 -20 -15 -10 -5 0 5
RELATIVE INTERFERENCE LEVEL [dB]

FIG. 9

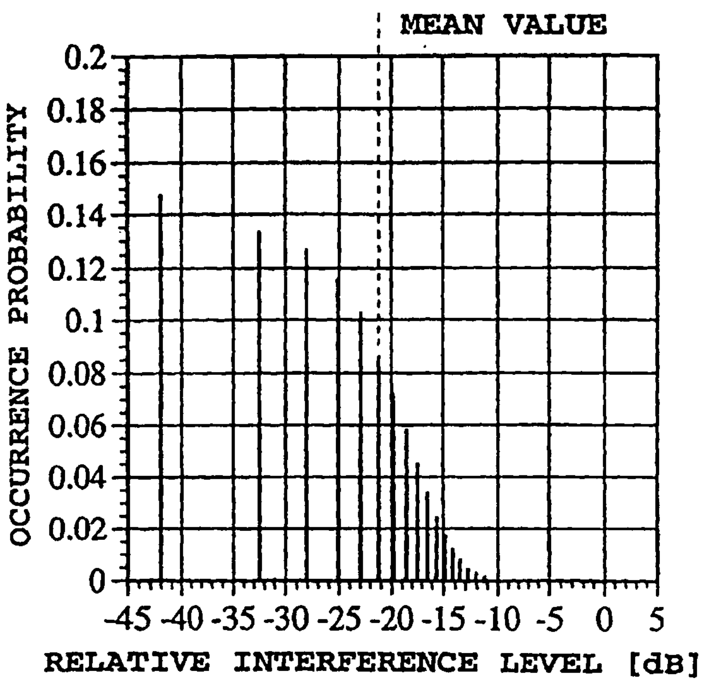

MEAN VALUE
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
OCCURRENCE PROBABILITY
-45 -40 -35 -30 -25 -20 -15 -10 -5 0 5
RELATIVE INTERFERENCE LEVEL [dB]

FIG.10

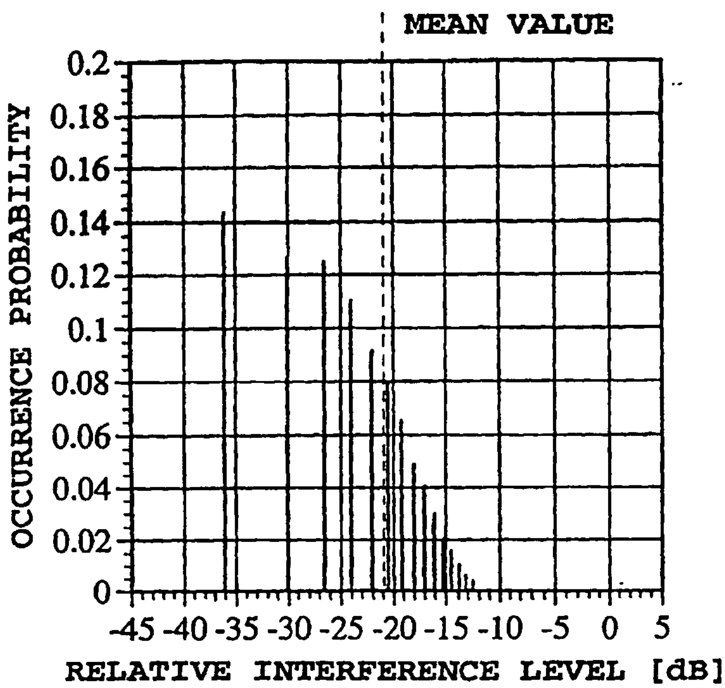

MEAN VALUE
OCCURRENCE PROBABILITY
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-45 -40 -35 -30 -25 -20 -15 -10 -5 0 5
RELATIVE INTERFERENCE LEVEL [dB]

FIG. 11

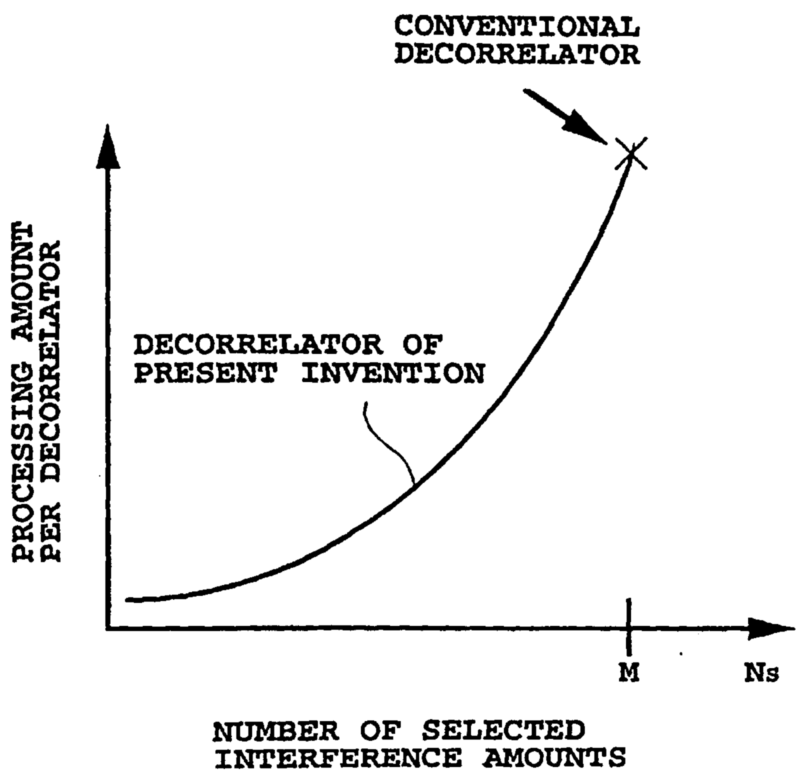

CONVENTIONAL
DECORRELATOR
PROCESSING AMOUNT
PER DECORRELATOR
DECORRELATOR OF
PRESENT INVENTION
M
Ns
NUMBER OF SELECTED
INTERFERENCE AMOUNTS

FIG.12

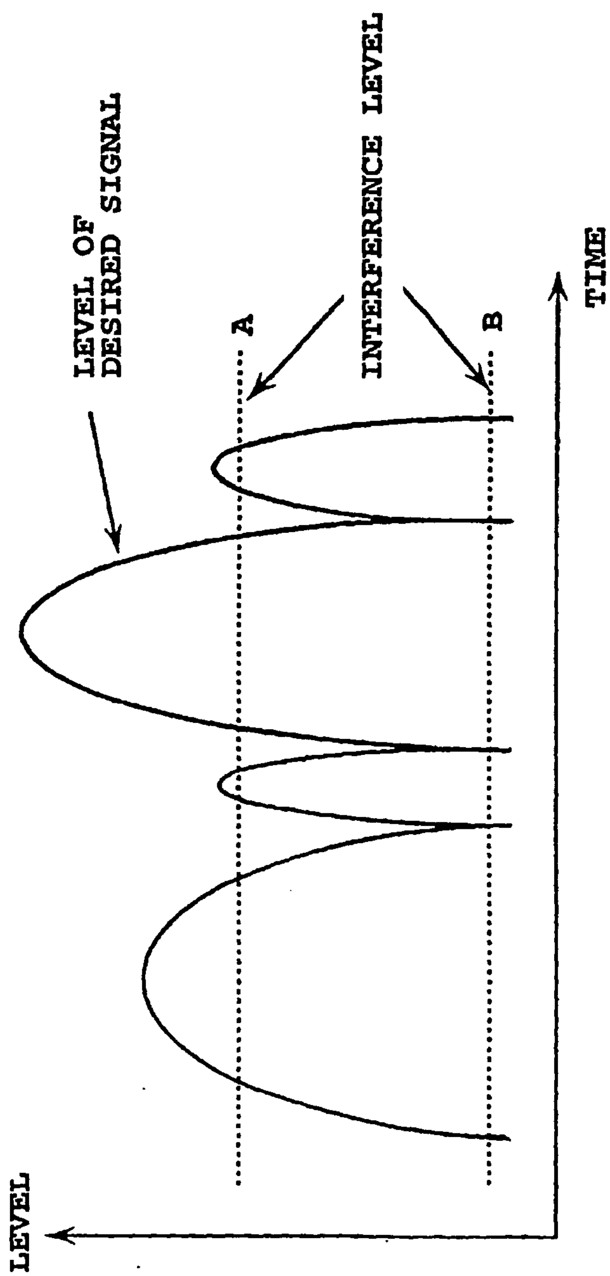
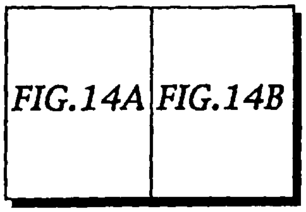


FIG.13

FIG.14



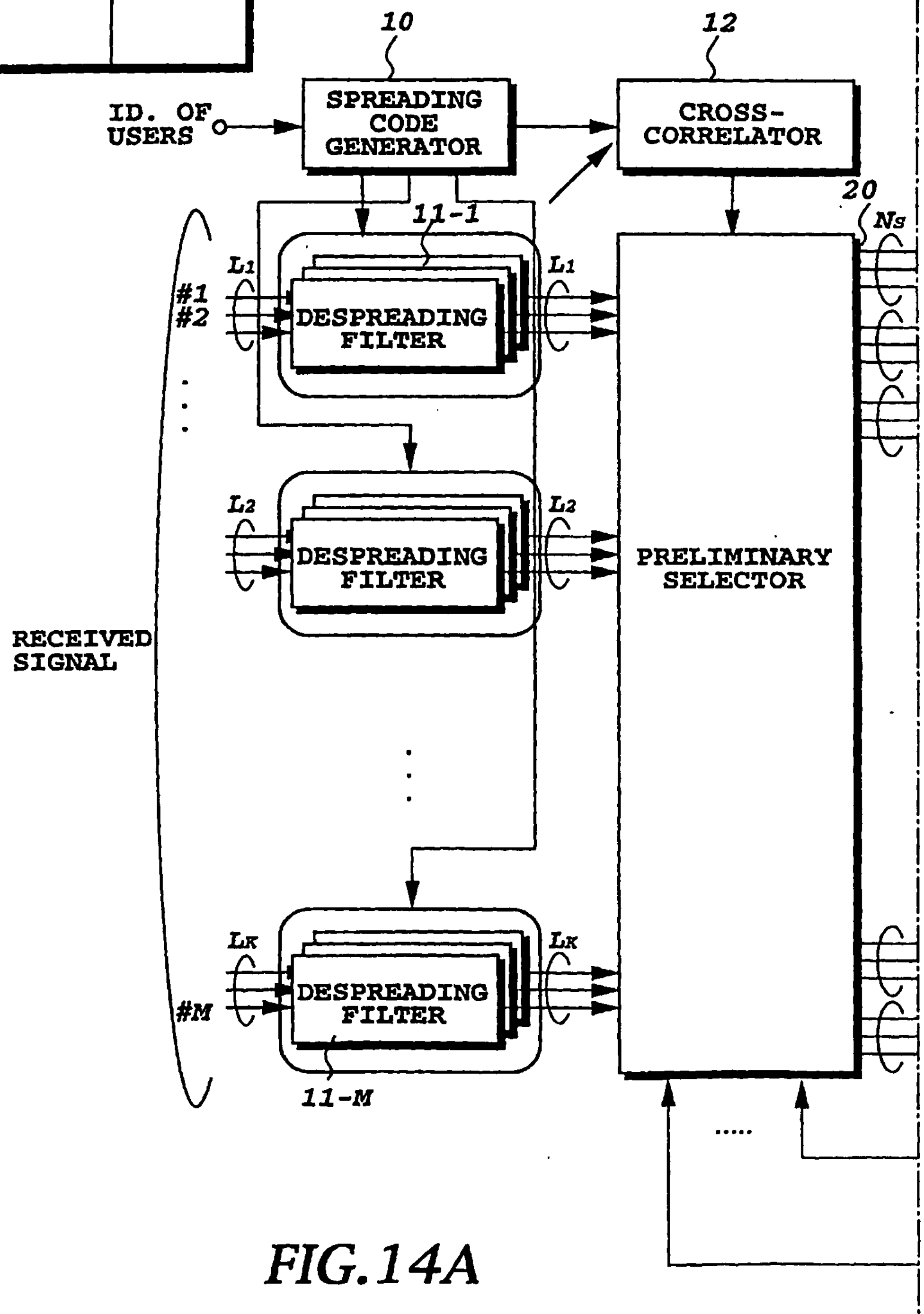
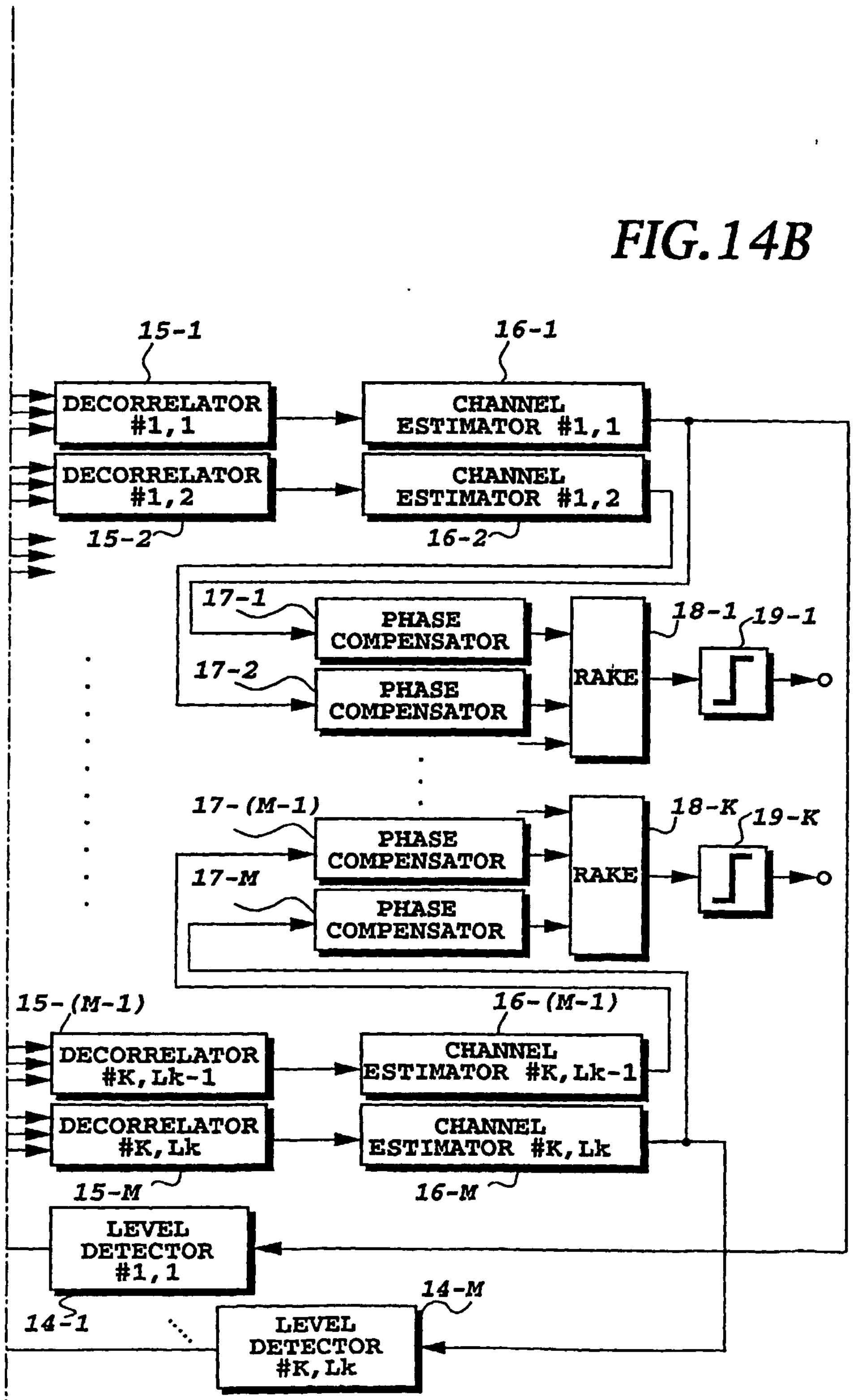


FIG.14A

FIG.14B


15-1
16-1
DECORRELATOR #1,1
CHANNEL ESTIMATOR #1,1
DECORRELATOR #1,2
CHANNEL ESTIMATOR #1,2
15-2
16-2
17-1
PHASE COMPENSATOR
17-2
PHASE COMPENSATOR
RAKE
18-1
19-1
17-(M-1)
PHASE COMPENSATOR
17-M
PHASE COMPENSATOR
RAKE
18-K
19-K
15-(M-1)
16-(M-1)
DECORRELATOR #K,Lk-1
CHANNEL ESTIMATOR #K,Lk-1
DECORRELATOR #K,Lk
CHANNEL ESTIMATOR #K,Lk
15-M
16-M
LEVEL DETECTOR #1,1
14-1
14-M
LEVEL DETECTOR #K,Lk